

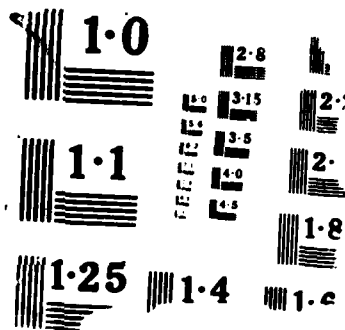
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DEMODULATION PROCESSES IN AUDITORY PERCEPTION

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1 March 1988

Interim Report for Period 1 December 1986 - 30 November 1987

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## ANNUAL TECHNICAL REPORT

Dec. 1, 1986 - Nov. 30, 1987

The overall goal of this project is to understand the ability of the human listener to track frequency modulations in speech, music or other environmentally important sounds. Specifically, we have devised a signal-processing model of this ability that is implemented on our laboratory minicomputer. The computer model calculates the Envelope-Weighted Average of the Instantaneous Frequency (EWAIF) for complex sounds. Our previous research with elementary signals indicated that a listener's ability to distinguish one complex sound from another can be predicted by determining the EWAIF value for each sound. Discriminability is then predictable from that listener's ability to distinguish one pure tone from another. In the current project, we have refined the computer model and we are testing its performance by comparing its predictions with the perceptual abilities of human listeners.

The revised model has the ability to track frequency changes (transitions) in complex sounds. These frequency transitions are thought to convey important information in the perception of speech, music and other sounds. For the revised model, we must determine a signal-processing time-frame. That is, a brief interval of time over which the model performs the EWAIF calculation. For on-going sounds, we assume that the listener's auditory system performs a running, short-term analysis of the complex sound. The signal-processing time-frame is the interval over which a brief sample of the sound is analyzed.

To test our revised model, we devised a new series of discrimination tests. Our listeners are asked to distinguish between two complex sounds. Each sound is frequency-modulated from an initial, to a final frequency. One sound moves from the initial to the final frequency over a smooth, linear trajectory; the other sound moves over a discrete, multiple-step path. As the number of steps increases, the duration and size of each individual step decreases. For a small number of steps, we expect that the listener will have no trouble distinguishing the smooth glide from the multiple-step sound. However, if our short-term analysis model is valid, we expect listeners to have greater difficulty in distinguishing the glide from the multiple-step sound when the number of steps is large. We plan to use the inability of our listeners to discriminate glide sounds from multiple-step sounds to guide our selection of the temporal parameters for the model.

Once we have determined the temporal parameters for the short-term analysis, we plan to move on to the difficult problem of wide bandwidth sounds. There is a flurry of activity in this area, characterized as "profile analysis" by David Green and his associates. We have shown in our preliminary work, that the EWAIF model has implications for the profile analysis work. Specifically, we suspect that much of the early work on "profile" signals is tainted by a stimulus artifact. Complex sounds synthesized from collections of sinusoids, as the early profile sounds were, have inherent amplitude and frequency fluctuations that are changed when one sinusoid is incremented in amplitude. Thus, we maintain that listener performance in the early profile analysis tasks

is confounded by a frequency modulation cue that alters the pitch of the complex sound when the "profile" of the background sound is altered. The fault in the profile analysis approach lies in the characterization of complex time functions by their long-term Fourier line spectra, and the notion that the auditory system processes the spectrum rather than the complex signal.

#### LIST OF RESEARCH OBJECTIVES AND CURRENT STATUS

1. Implement a short-term, tracking version of the EWAIF model on the laboratory minicomputer using the ILS signal processing package.

The model has been implemented as a two parameter short-term analyzer. That is, two temporal parameters are required to specify the analysis process. The two parameters are the time-frame, or window, and the lag. The lag indicates the temporal overlay from one analysis window to the next sequential one. We are currently converting the two parameter model into a one parameter model, by using a moving average filter instead of the window and lag process.

2. Begin the series of discrimination experiments that will be used to test the predictions of the short-term running EWAIF model.

Preliminary work using simple one-step versus glide discrimination was conducted in the spring semester of 1987. Over the summer term and fall semester, we have been testing listeners in the multiple-step vs. glide task. We began using signals in the 1000 Hz region, with transitions from 900 to 1100 Hz. Other frequency transitions in the 1000 Hz region and in other frequency regions will be tested in the spring semester of 1988.

#### PARTICIPATING PROFESSIONALS

Lawrence L. Feth, Ph.D.	Principal Investigator
Lisa J. Stover, M.A.	Graduate Research Assistant
Richard A. Gerren, Ph.D.	Post-doctoral Fellow (NIH)

#### PUBLICATIONS AND PRESENTATIONS

EWAIF: ENVELOPE-WEIGHTED AVERAGE OF INSTANTANEOUS FREQUENCY MODEL APPLIED TO COMPLEX SOUND PERCEPTION. L.L. Feth, L.J. Stover, and R.A. Gerren. Presented at the tenth mid-winter research meeting of the Association for Research in Oto-laryngology (ARO) Feb. 1987.

COMPLEX SOUND DISCRIMINATION PREDICTIONS: TEST OF THE EWAIF MODEL. L.L. Feth, L.J. Stover, and R. A. Gerren. Presented at the eleventh mid-winter research meeting of the ARO Feb. 1988.

AUDITORY TEMPORAL ACUITY MEASURED IN NORMAL HEARING LISTENERS USING TRANSIENT SIGNALS. R.A. Gerren, L.L. Feth, and L.J. Stover. Presented at the eleventh mid-winter research meeting of the ARO Feb. 1988.

## PATENTS AND INVENTIONS

No patentable inventions have resulted from this research project.

## STATEMENTS

A manuscript for submission to the Journal of the Acoustical Society of America is in preparation. We expect to submit it by late spring or early summer 1988.

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